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SURVIVAL AND EARLY GROWTH OF SELECTED TREES ON WASTE WATER APPLICATION SITES

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ABSTRACT. — The response of six tree species and three *Populus* hybrids to irrigation with oxidation pond effluent were compared. When weeds were intensively controlled, a *P. deltoides* x *P. nigra* cross responded best, but when weeds were less intensively controlled, *P. canescens* x *P. tremuloides* responded best.

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Land application of waste water has many advantages for small and medium sized communities, especially if construction and operating costs can be partially offset by growing crops on application sites. In the north-central United States, agricultural crops cannot be grown on many sites, because of the soil, terrain, and climate, but tree crops can be grown on most sites in the region. We conducted this study in the Lower Peninsula of Michigan, at Middleville and Harbor Springs, to evaluate the response of selected tree species and *Populus* hybrids to irrigation with oxidation pond effluent.

MIDDLEVILLE

The first test site was at Middleville in Barry County, on a gravelly morainal soil of the Boyer series, a typic hapludalf. Most of this site was nearly flat and had a plow layer of fine loamy sand. There were some slopes of more than 5 percent where surface soil had eroded exposing a gravelly sand, and part of the area was filled and covered with approximately 30 cm (1 foot) of very stony loamy sand.

Approximately 30mm (1.18 inches) and 70 mm (2.75 inches) of effluent was applied in 8 to 10 hours each week during the growing season. Nitrogen loading increased in 1975 and 1976 because concentration in the effluent increased sharply (table 1).

A split-plot design was used to test the effect of irrigation on the survival and growth of the trees. Application rate was the main plot treatment and subplots were planted to the species and hybrids selected for testing. In one set of nine plots each application rate and a control were replicated three times. In 1972, seedlings of *Populus*

Table 1. — *Nitrogen and phosphorus loadings for Middleville test plantings* (In kg/ha)

Year	30 mm/week	70 mm/week
	TOTAL N	
1972	33	77
1973	36	91
1974	36	85
1975	60	140
1976	52	123
	TOTAL P	
1972	19	45
1973	13	29
1974	13	31
1975	17	39
1976	20	48

canescens x *P. grandidentata* hybrid, Japanese larch *(Larix leptolepis)*, European larch*(Larix decidua)*, and tulip poplar *(Liriodendron tulipifera)* were planted in 25-tree subplots and northern red oak *(Quercus rubra)* seedlings were planted in a 28-tree subplot on each of the nine plots. Each application rate and the control were replicated twice in another set of six plots. Seedlings of green ash *(Fraxinus pennsylvanica)* and white-cedar *(Thuja occidentalis)* were each planted in two 25-tree subplots and 8-inch hardwood cuttings of 'Raverdeaux' poplar (a *P. deltoides* x *P. nigra* hybrid) were planted in one 28-tree subplot on each of these six plots. In 1973, a sixth 25-tree subplot in each plot of the nine-plot set was planted with hardwood cuttings of 'Raverdeaux' poplar taken from the 1972 planting. Spacing in all plots was approximately 1.2 m by 1.2 m (4 feet by 4 feet).

Plots were rototilled thoroughly before planting. Plots were not kept weed free but weed growth was greatly reduced by tilling, mowing, and using herbicides during the first 2 years.

Survival

The species and hybrids differed in their ability to survive without irrigation. Nearly all of the nonirrigated 'Raverdeaux' poplars planted in 1972 and 88 percent of the green ash were alive after five growing seasons (table 2) whereas only 65 percent of the *P. canescens* x *P. grandidentata* hybrid and 53 percent of the northern red oak survived without irrigation. Less than 50 percent of the other selections lived.

Irrigation increased survival of tulip poplar but had no significant effect on survival of any of the other selections planted in 1972. Apparently rainfall was adequate to prevent critical moisture stress during establishment. The 'Raverdeaux' poplar planted in 1973 survived significantly better with irrigation than it did without because there was not enough rain in 1973 to prevent critical moisture deficits on nonirrigated plots. Irrigation with 70 mm/week did not increase survival significantly more than irrigation with 30 mm/week.

Many of the *P. canescens* x *P. grandidentata* that died after the first year appeared to be girdled by a canker that has not yet been positively identified. Because cankers were only associated with mortality that occurred during the first 2 years and inoculation did not produce cankers in

Table 2. — *Survival, total height, and dry weight of selections included in Middleville test plantings after the 1976 growing season*

Selection	Survival			Total height			Total dry weight[1]		
	0	30 mm/week	70 mm/week	0	30 mm/week	70 mm/week	0	30 mm/week	70 mm/week
	Percent			*cm*			*kg*		
'Raverdeaux' poplar:									
Planted 1973	41 a[2]	85 b	89 b	183 a	443 b	542 b	0.221	2.144	3.601
Planted 1972	98 a	100 a	98 a	382 a	635 b	623 b	2.767	10.637	10.113
P. canescens x *P. grandidentata*	65 a	91 a	87 a	298 a	351 a	445 a	1.638	2.364	4.020
Green ash	88 a	93 a	93 a	163 a	260 b	219 b	0.495	1.675	1.070
Tulip poplar	24 a	59 b	67 b	157 a	249 a	242 a	0.282	1.145	1.050
European larch	21 a	29 a	24 a	128 a	192 a	258 a	0.135	0.431	1.004
Japanese larch	48 a	60 a	41 a	182 a	253 a	328 a	1.155	1.850	2.681
White-cedar	37 a	63 a	31 a	61 a	101 b	103 b	0.291	0.406	0.411
Red oak	53 a	67 a	61 a	113 a	104 a	142 a	0.168	0.141	0.275

[1]Dry weights are estimates based on average height using equations derived by weighing a random sample of 24 to 58 trees from each selection.

[2]Different letters following means for the same selection denote significant differences ($P \leq 0.10$).

vigorous 4-year-old trees, it appears that the canker only kills trees that are under stress during establishment.

Much of the mortality that occurred on irrigated plots was related to the grass and weeds that developed despite control efforts. Many of the Japanese larch that died during the first 3 years had sustained heavy feeding by June beetle larvae *(Phyllophaga* sp.*)*. The heaviest feeding was on irrigated plots that had the most herbaceous ground cover. Mice girdled many of the white-cedar on irrigated plots after weed control was stopped.

Growth

After five growing seasons, average height of nonirrigated trees ranged from about 1/2 m for white-cedar to nearly 4 m for the 'Raverdeaux' poplar (table 2). The average dry weight of whole trees ranged from 0.135 kg for European larch to 2.767 kg for 'Raverdeaux' poplar. The average height of all irrigated trees exceeded the average of those that were not irrigated, but the differences were only significant ($P < 0.10$) for 'Raverdeaux' poplar, green ash, and white-cedar. Irrigation increased the average height of these trees by 64, 46, and 67 percent, respectively, and their average dry weight by 275, 177, and 40 percent. Irrigation with 70 mm/week did not increase growth significantly more than irrigation with 30 mm/week.

Irrigation increased average height of the 'Raverdeaux' poplar planted in 1973 by 169 percent and its dry weight by nearly 1,200 percent. Again there was no significant difference in the effects of the two irrigation rates. The difference in response of the two 'Raverdeaux' plantings could be a reflection of differences in age or differences in weather during the year of establishment. However, it seems likely that removal of shoots from the first planting when it was 1 year old to provide cuttings for the second planting partially offset its response to irrigation.

HARBOR SPRINGS

The second test planting was on the application site for the Harbor Springs Area Sewage Disposal Authority near Petoskey in Emmet County. Soils were sands and loamy sands of the Kalkaska and Blue Lake Series, typic and alfic haplorthods, respectively, underlain at 45 to 120 cm (1.5 to 4 feet) with gravel. This site had a well established ground cover of grasses and forbes.

Populus hybrids were selected for a larger scale trial on this site because of their superior performance in the initial trial at Middleville. Nonrooted cuttings of 'Raverdeaux' poplar were planted as at Middleville, and some rooted cuttings were planted as well. *Populus canescens* x *P. tremuloides* was planted instead of *P. canescens* x *P. grandidentata* because it was thought to be more suited to the climate and soils at Harbor Springs. Instead of tilling to prepare for planting, a 2-foot strip was sprayed with a herbicide. Weed control after planting was much less intensive than it was at Middleville.

Each of the two hybrids was planted in two plots 36.6 m by 61.0 m (120 feet by 200 feet) and two that were 21.3 m by 61.0 m (70 feet by 200 feet). Rooted cuttings of 'Raverdeaux' poplar were planted in one of the smaller plots. Trees were spaced approximately 2.7 m by 2.7 m (9 feet by 9 feet). One-hundred and twelve 'Raverdeaux' poplars and 47 *P. canescens* x *P. tremuloides* seedlings were planted outside the irrigated area.

One half of each plot was irrigated at the rate of 3.9 mm (0.15 inch) per hour and the other half at the rate of 8.6 mm (0.34 inch) per hour (table 3).

Survival

After three growing seasons, 72 percent of the *P. canescens* x *P. tremuloides* seedlings on irrigated plots were still alive (table 4). Survival of nonirrigated seedlings was 89 percent.

Table 3. — *Annual effluent, nitrogen, and phosphorous loadings for two effluent application rates at Harbor Springs, Michigan*

Year	Effluent	N	P
	mm	*kg/ha*	
	3.9 mm/hour		
1974	604	13.2	11.9
1975	1,521	19.4	4.3
1976	3,871	206.0	77.2
	8.6 mm/hour		
1974	1,333	29.1	23.4
1975	3,354	39.0	8.5
1976	8,514	412.2	154.6

Table 4. — Populus *hybrids at Harbor Springs after three growing seasons*

Hybrid	Survival		Height	
	Not irrigated	Irrigated	Not irrigated	Irrigated
	Percent		*cm*	
P. canescens x *P. tremuloides*	89	72	61	120
'Raverdeaux' poplar	50	<1	--	--

Even though 92 percent of the rooted cuttings and 21 percent of the nonrooted cuttings of 'Raverdeaux' poplar planted on irrigated plots were alive after the first growing season, only 1 percent of the rooted cuttings and none of the nonrooted cuttings were alive after 3 years. Without irrigation, about 50 percent of the cuttings were still alive after 3 years.

The major causes of first year mortality were shading by grass and feeding by defoliators. Trees that survived the first year were girdled by mice. The rank grass that grew on irrigated plots seemed to provide a favorable habitat for both defoliators and mice. Grass was much shorter and less dense in nonirrigated plots.

Growth

Irrigation has nearly doubled growth of the *P. canescens* x *P. tremuloides* on this site. Irrigated trees average 120 cm in height after 3 years and nonirrigated trees averaged only 61 cm. 'Raverdeaux' poplar survival was so poor that we did not measure its growth.

SUMMARY AND CONCLUSIONS

The 'Raverdeaux' poplar has demonstrated the greatest response to effluent irrigation. If rainfall is abundant and well distributed throughout the growing season, irrigation is not necessary to establish nonrooted cuttings but it will greatly enhance establishment if moisture deficits occur. Field planting of nonrooted cuttings has not been successful without intensive weed control. But grass and weeds between tree rows probably serve as temporary storage sites for nitrogen and enhance denitrification.[1] Therefore, nitrogen losses associated with clean cultivation need to be evaluated.

Populus canescens x *P. grandidentata* grew faster than any of the other selections except 'Raverdeaux' poplar. *Populus canescens* x *P. tremuloides* seedlings were established successfully where neither rooted nor nonrooted cuttings of 'Raverdeaux' poplar were successful. If plantations are not to be cultivated intensively for the first year or two, a hybrid of *P. canescens* with one of the native species would be a better choice than the more demanding 'Raverdeaux' poplar.

Green ash is the only other selection that has demonstrated good survival and growth.

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[1]*Hook, James E. and Louis T. Kardos, 1977. Nitrate relationships in the Penn. State "Living Filter" system. p. 181-198. In Land as a waste management alternative. Raymond C. Loehr, ed. Ann Arbor Sci. Publ., Ann Arbor, Michigan.*